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Evaluation Note

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NCAP Test Improvements with Pretensioners and Load Limiters

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The goal of this evaluation was to determine what effect, if any, pretensioners and load limiters have on injury prevention. Safety belt pretensioners retract the safety belt almost instantly in a crash to remove excess slack. Energy management systems allow safety belts to yield in a crash, preventing the shoulder belt from directing too much energy on the chest of the occupant. Load limiters are the primary, but not only, energy management method used in safety belts. As part of determining their effectiveness, scores on frontal New Car Assessment Program (NCAP) tests were obtained for passenger cars and light trucks whose earlier models did not have pretensioners and/or load limiters but later included them as standard equipment. Changes in NCAP scores of these vehicles were compared to those of vehicles that did not add either pretensioners or load limiters (a “No Change” comparison group). The combination of pretensioners and load limiters is estimated to reduce (i.e., improve) Head Injury Criterion (HIC) by 232, chest acceleration by an average of 6.6 g’s, and chest deflection by 10.6 mm, for drivers and right front passengers. Each of these reductions is statistically significant. When looked at individually, pretensioners are more effective in reducing HIC scores for drivers and right front passengers, as well as chest acceleration and chest deflection scores for drivers. Load limiters show greater reductions in chest acceleration and chest deflection scores for right front passengers. By contrast, in make/models where neither load limiters nor pretensioners were added, there was little change during 1998 to 2001 in HIC, chest acceleration, or chest deflection values in NCAP tests.

To minimize the influence of air bag modifications on NCAP scores, only vehicles of model year 1998 and later were selected (i.e., most vehicles had depowered air bags). Although air bag improvements continued to be made after that point, the changes were less dramatic between 1998 and 2001. Vehicles that had gone through a major redesign concurrently with adding pretensioners and/or load limiters were excluded from the analysis. The addition of pretensioners and/or load limiters, or the lack of change, refers specifically to changes in vehicles between available NCAP tests. Only full-frontal barrier impact tests at 35 mph, using 50th percentile male Hybrid III dummies, were used. In all, there were three vehicles that added only pretensioners from one available NCAP test to the next, and five that added only load limiters. Ten vehicles added both pretensioners and load limiters, and fourteen had no change. Both passenger cars as well as light trucks were included in the analysis.

For drivers and right front passengers combined, all ten make/models that added both pretensioners and load limiters experienced reductions in HIC, chest acceleration, and chest deflection. In addition, in the eight make/models that added only pretensioners or only load limiters, all showed improvement in chest acceleration scores, while six showed improvement in HIC. Only one vehicle did not show

improvement in chest deflection scores, although in two cases data were not available for the comparison. In vehicles with no change in either technology, only four of the fourteen saw a reduction in HIC. Eight of these fourteen vehicles experienced a reduction in chest acceleration scores, and eight had a reduction in chest deflection scores. However, the decreases are much smaller than those seen in the groups of vehicles adding one or both belt technology.

A regression analysis was performed to quantify the improvements due to the addition of load limiters and pretensioners. Difference scores (the change in NCAP scores after load limiters and/or pretensioners were added, or between the earlier and later NCAP scores in those make/models with no change) were used. HIC scores were significantly reduced after the installation of pretensioners regardless of seating position – driver and right front passenger individually as well as combined. In addition, HIC scores for drivers were significantly lower after the addition of load limiters. Both chest acceleration and chest deflection scores were significantly lower for right front passengers alone as well as in combination with drivers after the installation of load limiters, while the same scores for drivers were significantly lower after the introduction of pretensioners. Additionally, drivers and right front passengers combined had lower chest deflection scores after pretensioners were added. Other analyses suggest that the effects of load limiters and pretensioners are simply additive (i.e. there is no significant interaction). Therefore, the effects can be summed. For drivers and right front passengers combined, the combination of pretensioners and load limiters reduced HIC by an average of 232 per occupant (154 due to pretensioners plus 78 due to load limiters). The reduction in chest acceleration was 2.9 g's due to pretensioners plus 3.7 g's due to load limiters, for a total of 6.6 g's. Chest deflection scores were reduced by 5.6 mm due to pretensioners and 5.0 mm due to load limiters, for a total of 10.6 mm.

It is evident that pretensioners are especially valuable in lowering HIC scores as well as chest acceleration and chest deflection scores for drivers, while load limiters appear to have more of an influence lowering chest acceleration and chest deflection scores for right front passengers. When neither load limiters nor pretensioners were added, HIC and chest acceleration values changed little from year to year in NCAP tests. The improvements seen when pretensioners and/or load limiters are added appear to be due to these technologies, and not to other safety features added during this time or to a change in NCAP testing or instrumentation.

Currently not enough real-world crash data exist to permit an analysis of the effects of adding pretensioners and/or load limiters to passenger vehicles. Approximately 63 percent of the model year 2002 fleet of vehicles was equipped with pretensioners, and approximately 84 percent was equipped with load limiters or other energy management features for safety belts. When enough data are available, a follow-up report will use NHTSA's injury and fatality crash data files to determine the effect these belt technologies have in actual crashes, as well as updating NCAP test information.

A more detailed technical report is available, with full information on actual NCAP scores and NCAP score differences before and after the introduction of belt technologies. Statistical results of mean difference tests and additional regression analyses supporting the results presented here are also provided.

For more information about this study, additional copies of this evaluation note, or the technical report on which it is based (DOT-HS 809 562, March 2003) please contact Charles J. Kahane at 202-366-2560, FAX: 202-366-2559. This note and other NHTSA evaluations may be viewed at www.nhtsa.dot.gov/cars/rules/regrev/evaluate.